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# DIODE

# STEP STRESS TESTING PROGRAM

MSFC/NASA CONTRACT NUMBER
NAS8-31944

FINAL REPORT
FOR
JANTX 1N1202A

JANUARY 1979

Prepared
For

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## FOREWORD

This report is a summary of the work performed on NASA Contract NAS8-31944. The investigation was conducted for the National Aeronautics and Space Administration, George C. Marshall Space Flight Center, Huntsville, Alabama. The Contracting Officer's Technical Representative was Mr. F. Villella.

The short-term objective of this preliminary study of transisters, diodes, and FETS is to evaluate the reliability of these discrete devices, from different manufacturers, when subjected to power and temperature step stress tests.

The long-term objective is to gain more knowledge of accelerated stress testing for use in future testing of discrete devices, as well as to determine which type of stress should be applied to a particular device or design.

This report is divided as follows: description of tests, figures, tables, and appendix.

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## 1.0 INTRODUCTION

DCA Reliability Laboratory, under Contract NAS8-31944 for NASA/Marshall Space Flight Center, has compiled data for the purpose of evaluating the effect of power/temperature step stress when applied to a variety of semiconductor devices. This report covers the switching diode JANTX-1N1202A manufactured by General Electric and International Rectifier.

A total of 48 samples from each manufacturer were submitted to the process outlined in Table 1. In addition, two control sample units were maintained for verification of the electrical parametric testing.

## 2.0 TEST REQUIREMENTS

### 2.1 Electrical

All test samples were subjected to the electrical tests outlined in Table 2 after completing the prior power/temperature step stress point. These tests were performed using the Fairchild Model 600 High-speed Computer-controlled Tester. Additional bench testing was also required on the devices.

### 2.2 Stress Circuit

The test circuit in Figure 1 was used to power all of the test devices during the power/temperature stress conditions. The voltage was set by $V_F$ and the current was varied in order to comply with the specified power rating for this device. At least one of the devices was subjected to a maximum rated power (MRP). All remaining devices were

subjected to no less than 90% of MRP. See Figure 1 for load resistance values and voltages.

2.3 Group I - Power Stress

Thirty-two units, 16 from each manufacturer, were submitted to the Power Stress Process. The diodes were stressed in 500-hour steps at 50, 100, 125, 150 and 175 percent of maximum rated power for a total of 2500 hours or until 50% or more of the devices in a sample lot failed.* Electrical measurements were performmed on all specified electrical parameters after each temperature step. See Table 1. (*See Notes at end of text.)

2.4 Group II - Temperature Stress I.

Thirty-two units, 16 from each manufacturer, were submitted to the Temperature Stress I Process. Group II was subjected to 1600 hours of stress at maximum rated power in increments of 160 hours. The temperature was increased in steps of 25°C, commencing at 75°C and terminating at 300°C or until 50% or more of the devices failed. Electrical measurements were performed on all specified electrical parameters after each temperature step. See Table 1.

2.5 Group III - Temperature Stress II

Thirty-two units, 16 from each manufacturer, were submitted to the temperature Stress II Process. Group III was subjected to 112 hours of stress at maximum rated power in increments of 16 hours. The temperature was increased in steps of 25°C, commencing at 150°C and terminating at 300°C or until 50% or more of the devices in a sample lot

failed.* Electrical measurements were performed on all specified electrical parameters after each temperature step. See Table 1.

## 3.0 DISCUSSION OF TEST RESULTS

### 3.1 Group I - Power Stress

#### 3.1.1 General Electric

The General Electric sample lot completed the entire 2500-hour Group I Testing with four catastrophic failures. The first two failures occurred 50 hours into the 100 percent MRP step. Serial Numbers 9312 and 9319 failed because of excessive $I_R$ leakage. The next failure occured 500 hours into the 125 percent MRP step. Serial Number 9307 failed because of excessive $I_R$ leakage. The final failure occurred 500 hours into the 150 percent MRP step. Serial Number 9315 failed due to excessive $I_R$ leakage. Typical characteristics of this sample lot's performance were:

1) The mean value for $I_R$ changed 7.799 µA from an initial mean of 2.841 µA to a final mean of 10.64 µA.
2) The mean value for $V_F$ changed 79.0mV from an initial mean of 1.176V to a final mean of 1.097V.

The control units for this sample lot remained constant throughout the entire Group I Testing.

#### 3.1.2 International Rectifier

The INR sample lot completed 2010 hours before the lot was stopped because of a failure rate of 50 percent of the lot. The first five failures occurred 50 hours into the 100 percent MRP step.

Serial Numbers 9365, 9366, 9368 and 9372 failed because of excessive $I_R$ leakage. Serial Number 9367 failed the maximum $V_F$ limit. The next two failures occurred 250 hours into the 150 percent MRP step. Serial Numbers 9362 and 9363 failed due to excessive $I_R$ leakage. The last failure occurred 500 hours into the 150 percent MRP step. Serial Number 9364 failed the maximum $V_F$ limit. Typical characteristics of this sample lot's performance were:

1) The mean value for $I_R$ changed 482.5nA from an initial mean of 332.7nA to a final mean of 815.2nA.

2) The mean value for $V_F$ changed 16.0mV from an initial mean of 1.114V to a final mean of 1.130V.

The control units for this sample lot remained constant throughout the entire Group I Testing.

3.1.3 Statistical Summary - Group I

Table 4 outlines the results of Group I - Power Stress Process for the two electrical parameters and all measurement points for both General Electric and International Rectifier.

3.2 Group II - Temperature Stress I

3.2.1 General Electric

The GE sample lot completed 960 hours before the lot was stopped because of a failure rate exceeding 50% of the lot. The first failure occurred 160 hours into the 150°C-temperature steps. Serial Number 9347 failed due to excessive $I_R$ leakage. The next failure occurred 160 hours into the 175°C-temperature step. Serial Number 9351 also failed because of excessive $I_R$

leakage. The last ten failures occurred 160 hours into the 200°C-temperature step. Serial Numbers 9339, 9340, 9341, 9342, 9345, 9346, 9348, 9349, 9350 and 9353 all were removed from the testing as visual rejects because the anode leads detached due to stress. Typical characteristics of this lot's performance were:

1) The mean value for $I_R$ changed 5.70nA from an initial mean of 247.9nA to a final mean of 253.6nA.

2) The mean value for $V_F$ changed 54.0 mV from an initial mean of 1.202V to a final mean of 1.256V.

The control units for this sample lot remained constant throughout the Group II Testing.

3.2.2 International Rectifier

The INR sample lot completed 160 hours before the lot was stopped because of nine visual failures. Serial Numbers 9391, 9401 and 9405 were rejected because the anode leads detached due to stress. Serial Numbers 9395,9393, 9400, 9402, 9403 and 9408 were removed because the anode leads brode off due to handling. Typical characteristics of this sample lot's performance were:

1) The mean value for $I_R$ changed 53.64nA from an initial mean of 40.36nA to a final mean of 94.00nA.

2) The mean value for $V_F$ changed 35.0mV from an initial mean of 1.269V to a final mean of 1.304V.

The control units for this sample lot remained constant throughout the Group II Testing.

3.2.3 Statistical Summary - Group II

Table 5 of this report outlines the results of Group II - Temperature Stress I testing for the two electrical parameters and all of the

measurement points pertaining to General Electric and International Rectifier.

3.3 Group III - Temperature Stress II

3.3.1 General Electric.

The GE sample lot completed the entire 112-hour Group III Testing with a total of two catastrophic failures. Both failures occurred 16 hours into the 275°C-temperature step. Serial Numbers 9324 and 9328 failed because of excessive $I_R$ leakage. Typical characteristics of this lot's performance were:

1) The mean value for $I_R$ changed 32.74μA from an initial mean of 175.6nA to a final mean of 32.92μA.
2) The mean value for $V_F$ changed 70.0mV from an initial mean of 1.168V to a final mean of 1.238V.

The control units for this sample lot remained constant throughout the Group III Testing.

3.3.2 International Rectifier. The INR lot completed the entire 112-hour Group III testing with four catastrophic failures. Two devices were pulled 16 hours into the 200°C-temperature step. Serial Numbers 9379 and 9390 were removed from the testing as MIL-S-19500 limit failures at this point. The first two catastrophic failures occurred 16 hours into the +250°C temperature step. Serial Numbers 9383 and 9386 failed because of excessive $I_R$ leakage. Two devices were pulled 16 hours into the 200°C temperature step. Serial Numbers 9379 and 9390 were removed from the testing as MIL-S-19500 limit failures at this point. Serial Number 9382 was removed from the

testing as a MIL-S-19500 limit failure. The last two catastrophic failures occcurred 16 hours into the +275°C temperature step. Serial Numbers 9387 and 9388 failed because of excessive $I_R$ leakage. Serial Number 9382 was removed from the testing as a MIL-S-19500 limit failure. Serial Number 9384 was removed from the testing as a MIL-S-19500 limit failure. Typical characteristics of this lot's performance were:

1) The mean value of $I_R$ changed 38.13μA from an initial mean of 203.5nA to a final mean of 38.33μA.
2) The mean value of $V_F$ changed 56.0mV from an initial mean of 1.109V to a final mean of 1.165V.
The control units for this sample lot remained constant throughout the entire Group III Testing.

3.3.3 Statistical Summary - Group III. Table 6 outlines the results of Group III - Temperature Stress II testing for the two parameters and all of the measurement points pertaining to both General Electric and International Rectifier.

4.0 FINAL DATA SUMMARY

Table 7 statistically summarizes the change in the mean value from the zero-hour data to the final data. The graphs of Figures 2 and 4 plot the cumulative percent failures versus the temperature stress level for Group II - Temperature Stress I, and Group III - Temperature Stress II. The graphs of Figures 3 and 5 plot the time step for Group II (160 hours) and Group III (16 hours) versus the temperatures $T_1$ and $T_2$ calculated from Figures 2 and 4. Tables 8 and 9 summarize the failures

encountered for all three stress groups. The failures are separated into two catagories: catastrophic failures in Table 8 and parametric failures in Table 9. The data from Table 8 was used as a source for the graphs in Figures 2 and 4. Figures 2 and 4 were used as a source for the graphs in 3 and 5 respectively. Junction temperature is plotted on an inverse hyperbolic scale.

## 5.0 CONCLUSIONS

The Group II - Temperature Stress I Testing proved to be the most damaging to both General Electric and International Rectifier (INR). The INR sample lot also showed signs of weakness in the Power Stress - Group I Testing. In this testing, the INR diodes seem to have failed due to thermal effects from the excess Power Stress Test. The failure modes included metal melting which disconnected and shorted internal die connections, and alloying of metal with the silicon. In the Group II Testing, many visual failures were seen from both manufacturers. These visual failures suggest that both the International Rectifier and General Electric devices failed because they were unable to withstand the high temperature developed by the Thermal Stress Test. There was universal failure of the seal between the tubulation and glass.

The General Electric devices also exhibit a major weak point where the internal wire lead is attached to the active cell.

A plot showing cumulative failure distribution for Groups II and III was drawn for the General

Electric sample lot (Figures 2 and 3), but a plot for the International Rectifier sample lot could not be drawn due to an absence of failure points in the Group II Testing (Figures 4 and 5). Figures 2 and 3 display the data for the General Electric sample lot used to calculate an activation energy of 1.18eV.
A broken circle around a marked point on the graph indicates a freak failure not calculated as part of the regression line. A solid circle around a marked point indicates an isolated failure point. The regression line was drawn using the least square method.

The activation energy was calculated from the formula:

$$E = \left[ \ell n \left( \frac{t_1}{t_2} \right) \right] \left[ \frac{8.63 \times 10^{-5} \text{ eV/}^{\circ}\text{K}}{\left( \frac{1}{T_1+273} \right) - \left( \frac{1}{T_2+273} \right)} \right] \text{eV}$$

Where: $t_1$ = step of Group II - Temp Stress I =160 hrs.

$t_2$ = step of Group III - Temp Stress II = 16 hrs.

$T_1$ = temperature in $^{\circ}$C of 16% failure for Group II.

$T_2$ = temperature in $^{\circ}$C of 16% failure for Group III.

NOTE:

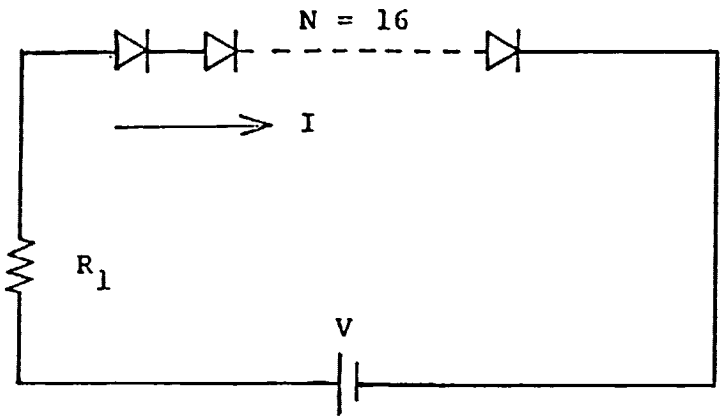
* Conditions for failure:

A) Open or short

B) Leakage exceeds the maximum limit by 100 times

C) Other parameters exceed MIL limits by 50% or more.

SWITCHING DIODES

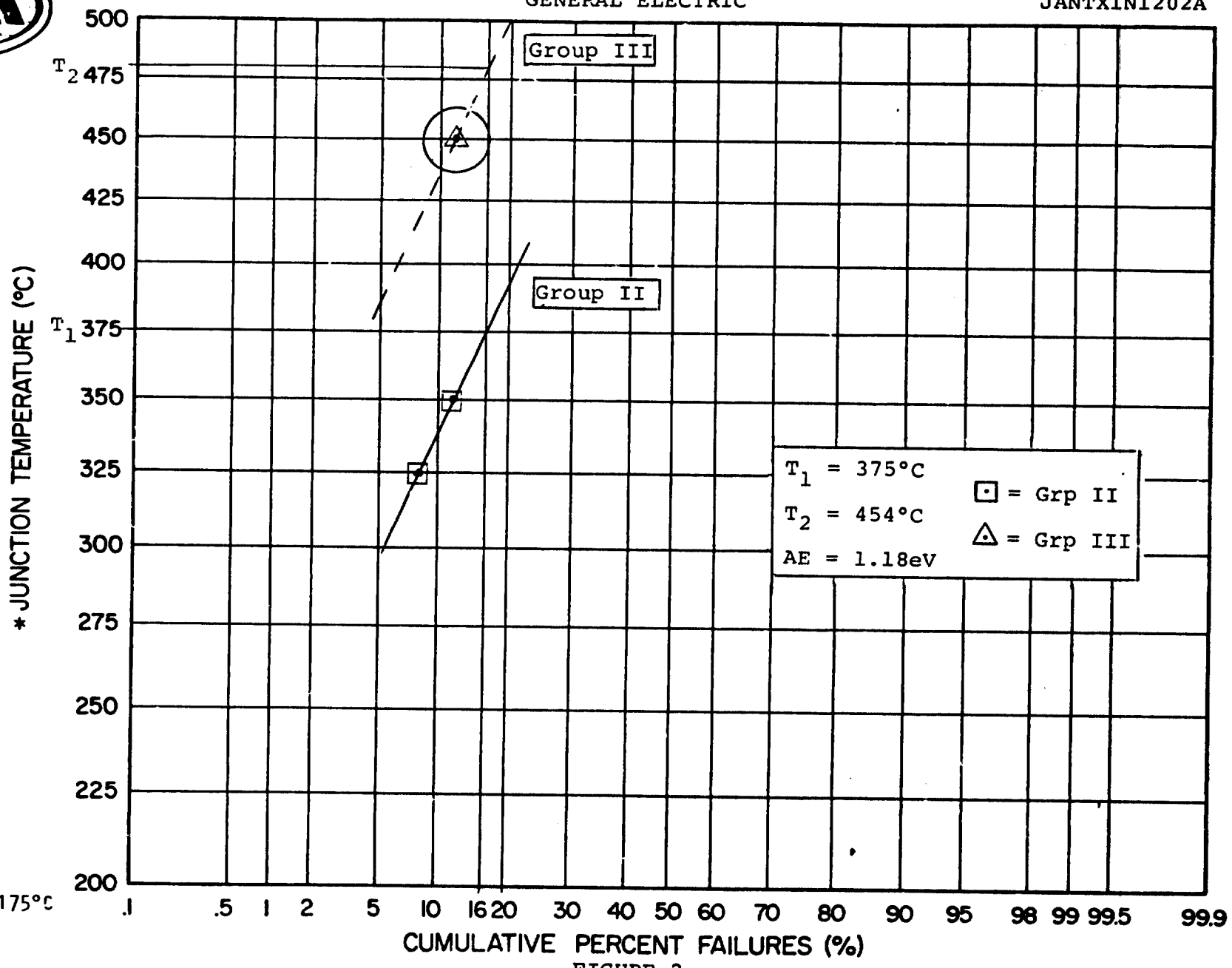



$R_1 = 1V/I \pm 1\%$

$P_d = IE$

FIGURE 1

Power and Temperature Stress Circuit
for JANTX1N1202A




*NOTE

$T_J \approx T_A + 175°C$

FIGURE 2
Cumulative Percent Failures Versus Junction Temperature, General Electric

JANTX1N1202A

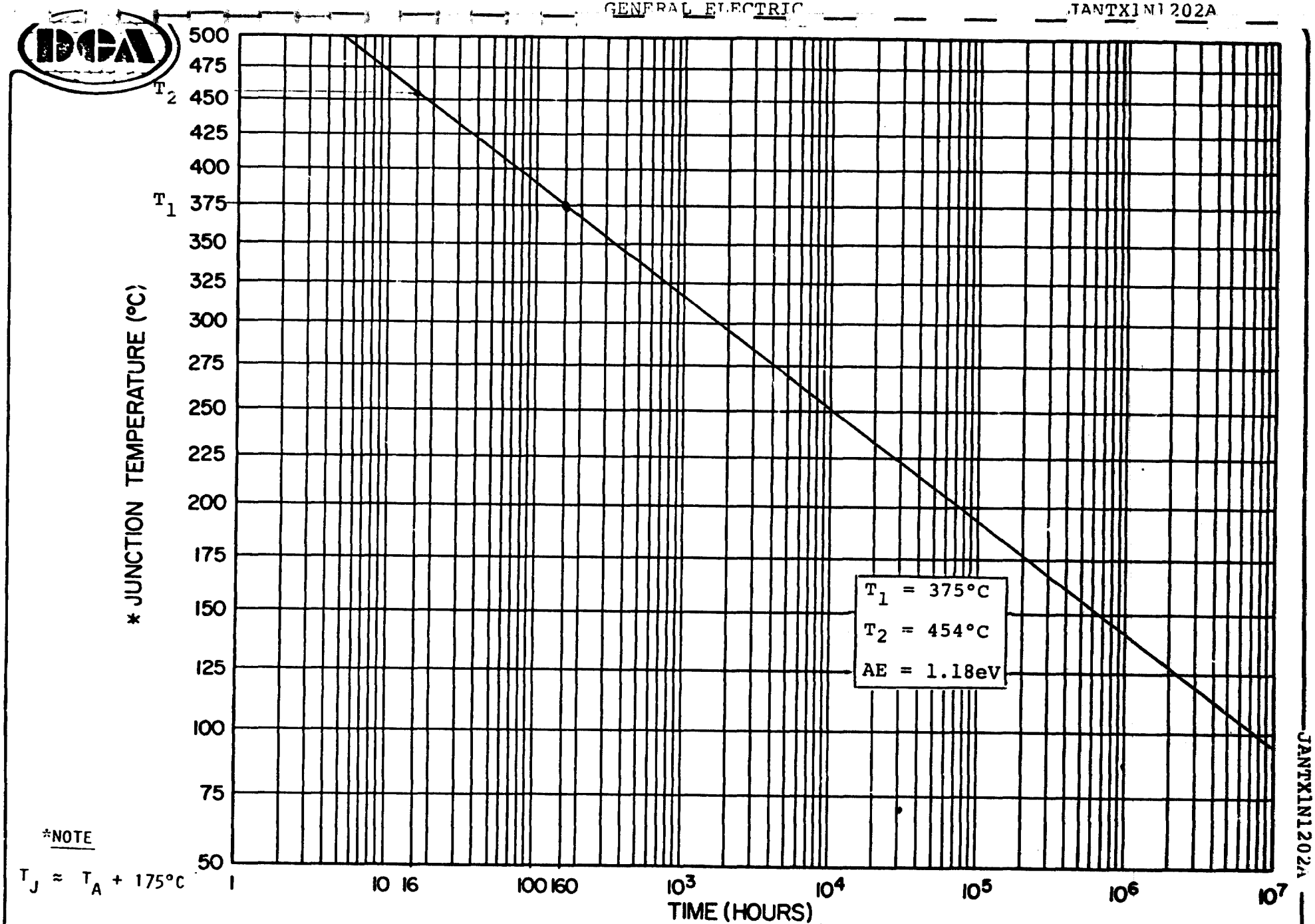
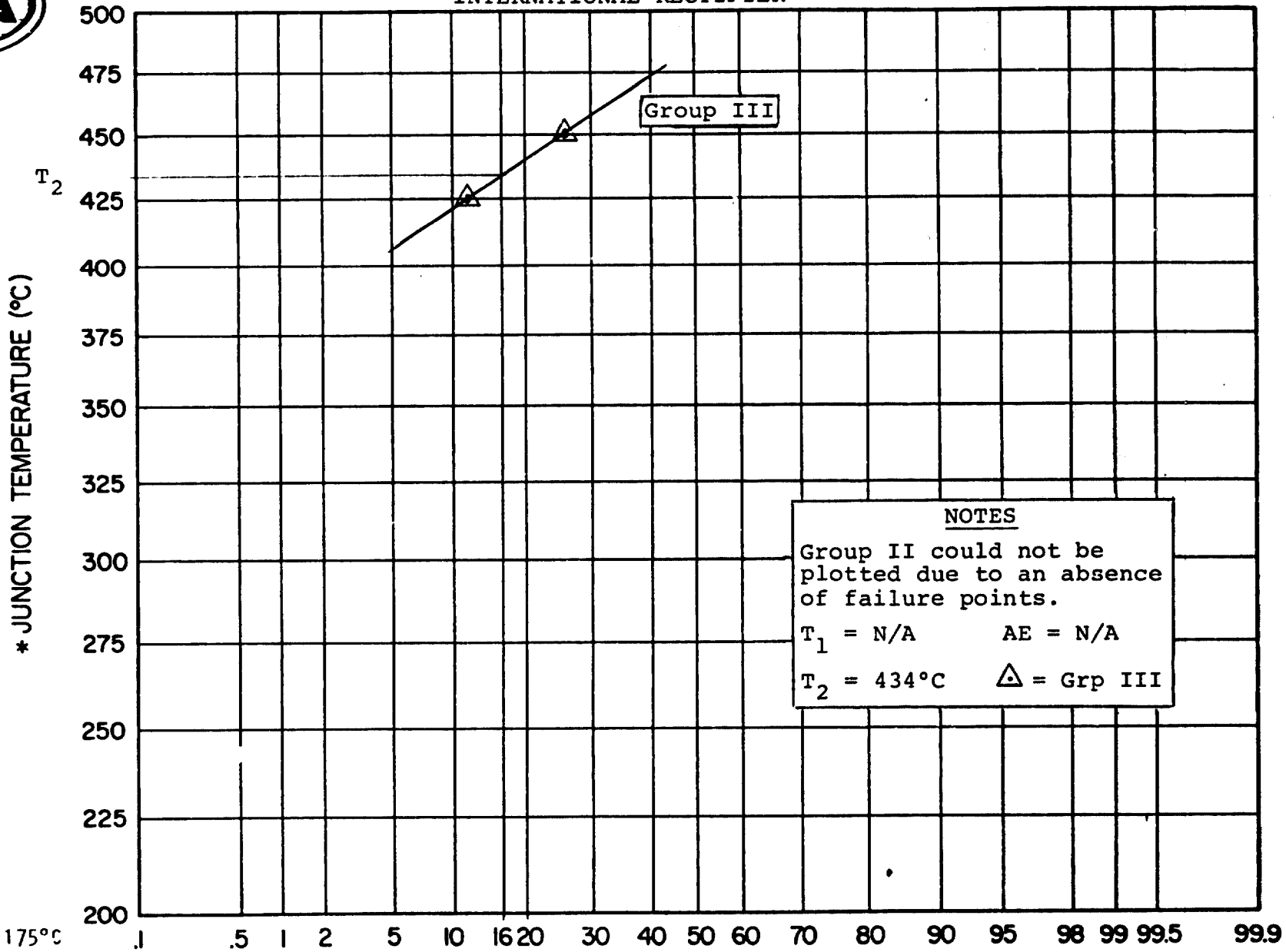



FIGURE 3

Time Steps Versus Junction Temperature, General Electric




*NOTE

$T_J \approx T_A + 175°C$

FIGURE 4

Cumulative Percent Failures Versus Junction Temperature, International Rectifer

JANTX1N1202A

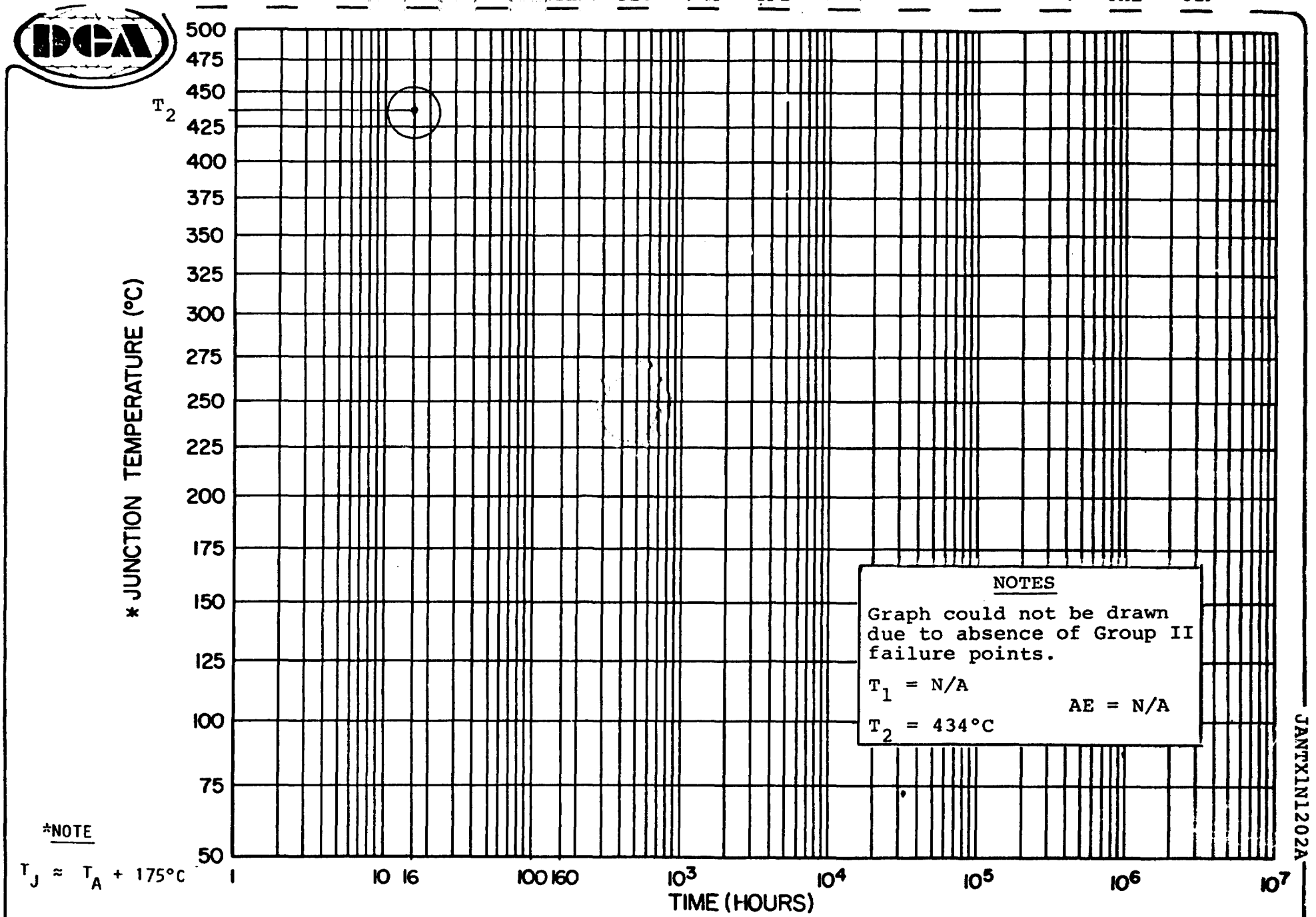
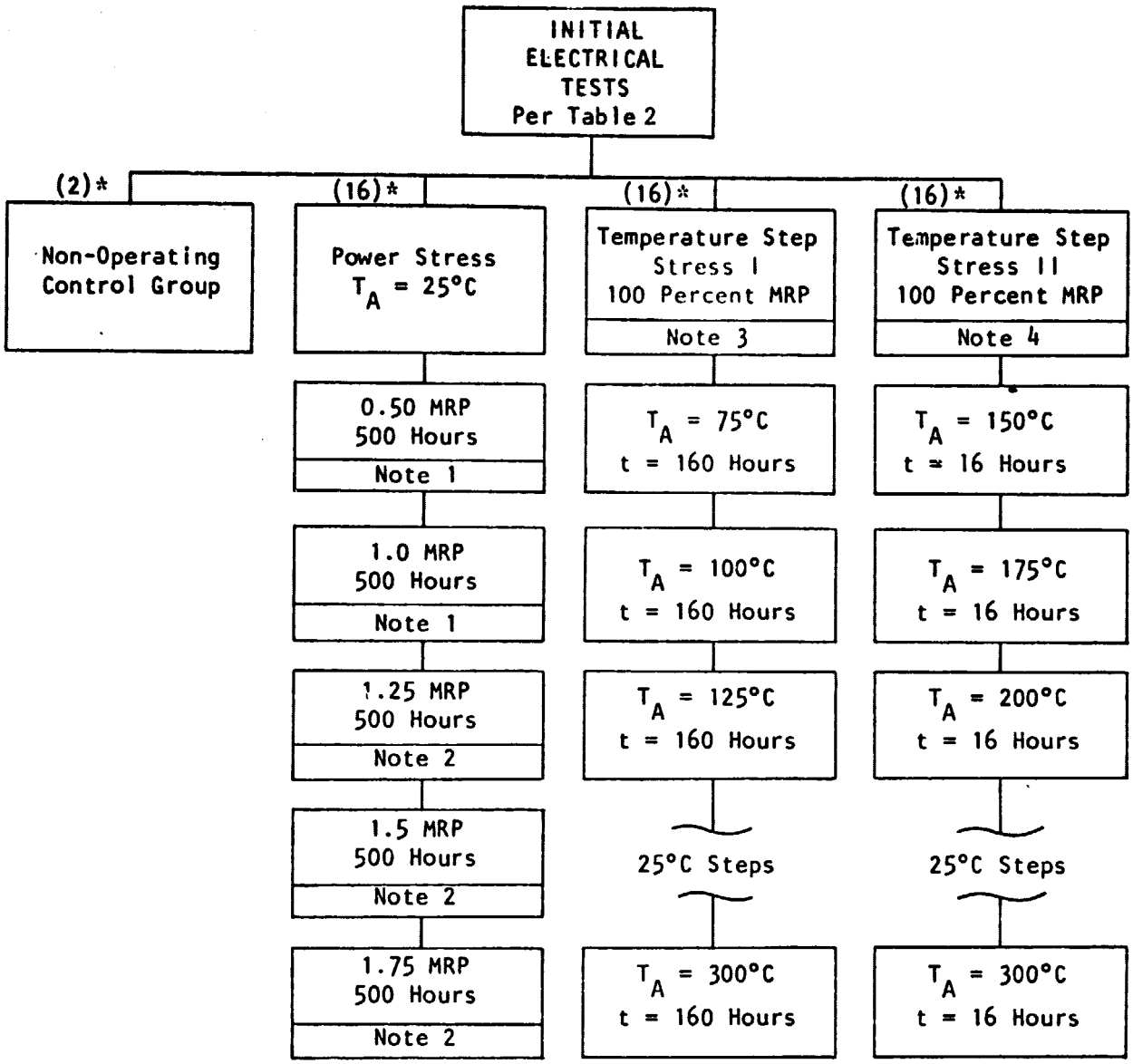



FIGURE 5

Time Steps Versus Junction Temperature, International Rectifier

TABLE 1
TEST FLOW DIAGRAM




*Quantity per manufacturer (GENERAL ELECTRIC & INTERNATIONAL RECTIFIER)

NOTES:

1) Electrical measurements per Table 2 were made at 50, 150, 250 and 500 hours.
2) Electrical measurements per Table 2 were made at 10, 25, 50, 150, 250 and 500 hours.
3) Electrical measurements per Table 2 were made at the end of each 160 hours.
4) Electrical measurements per Table 2 were made at the end of each 16 hours.

TABLE 2
PARAMETERS AND TEST CONDITIONS

| PARAMETER | CONDITIONS | SPEC. LIMIT | | CAT. LIMIT | | UNITS |
|---|---|---|---|---|---|---|
| | | MIN | MAX | MIN | MAX | |
| $I_R$ | @ $V_R$ = 200V | | 50 | | 5000 | µA |
| $V_F$ | @ $I_F$ = 38A(PK) PULSED | | 1.35 | | 2.025 | V(PK) |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

NOTES:
1/ In addition, any open or short shall be considered catastrophic.

TABLE 3
POWER STRESS BURN-IN CONDITIONS

| $V_F$ = 1.0V | |
|---|---|
| $I_F$ = | Percent $P_D$ |
| 3.0A | 50 |
| 6.0A | 100 |
| 7.5A | 125 |
| 9.0A | 150 |
| 10.5A | 175 |

NOTE
FOR TABLES
4 THROUGH 7

The minimum/maximum initial and final data generally have an absolute accuracy of ±1% of the reading and ± one digit except for readings greater than 9.99mA which have an absolute accuracy of ±2% of the reading and ± one digit. The data also have a resolution for four digits. The standard deviations, means, delta means, and average means are, therefore, valid indicators of trends over time and temperature, excepting the minor statistical computer error of supplying a constant number of significant digits.

TABLE 4
GROUP I – POWER STRESS DATA SUMMARY



| PARAMETER | $I_R$ = 50μA(MAX) | | $V_F$=1.35V(MAX)(PK) | | | | | |
|---|---|---|---|---|---|---|---|---|
| CONDITIONS AND LIMIT | $V_R$ = 200V | | $I_F$=38A(PK) (PULSED) | | | | | |
| IDENTIFICATION | GE | INR | GE | INR | | | | |
| INITIAL DATA | | | | | | | | |
| MIN VALUE | 52.10nA | 2.130nA | 1.144V | 1.064V | | | | |
| MAX VALUE | 42.60μA | 4.330μA | 1.215V | 1.195V | | | | |
| MEAN | 2.841μA | 332.7nA | 1.176V | 1.114V | | | | |
| STD DEV | 10.27μA | 1.049μA | 21.95mV | 32.41mV | | | | |
| INTERIM DATA | | | | | | | | |
| POWER 50 TO 125% Δ MEAN VALUE | | | | | | | | |
| 50% POWER | | | | | | | | |
| 50 HRS | -.754μA | -247.2nA | -0.00V | 3.0mV | | | | |
| 150 HRS | -.825μA | -168.0nA | 2.00mV | 12.0mV | | | | |
| 250 HRS | -.375μA | -171.3nA | 63.40mV | 9.0mV | | | | |
| 500 HRS | -.495μA | -218.0nA | 9.00mV | 11.0mV | | | | |
| 100% POWER | | | | | | | | |
| 550 HRS | *2.221μA | *1.465μA | 3.00mV | 6.0mV | | | | |
| 650 HRS | 2.944μA | 1.212μA | 3.00mV | 24.0mV | | | | |
| 750 HRS | 6.923μA | -44.80nA | 8.00mV | 29.0mV | | | | |
| 1000 HRS | -2.667μA | 168.6nA | -0.00V | 37.0mV | | | | |
| 125% POWER | | | | | | | | |
| 1010 HRS | -2.431μA | 335.0nA | 3.00mV | 30.0mV | | | | |
| 1025 HRS | -2.374μA | -70.30nA | 15.00mV | 39.0mV | | | | |
| 1050 HRS | -1.469μA | -103.7nA | 11.00mV | 39.0mV | | | | |
| 1150 HRS | -.303μA | 2.317μA | 9.00mV | 36.0mV | | | | |
| 1250 HRS | 2.241μA | -91.90nA | 9.00mV | 38.0mV | | | | |
| 1500 HRS | *713.6μA | -329.6nA | 8.00mV | 36.0mV | | | | |

(continued on second sheet)

TABLE 4 (Cont'd)

(continued from first sheet) GROUP I — POWER STRESS DATA SUMMARY



| PARAMETER | $I_R$ = 50μA (MAX) | | $V_F$ = 1.35V(MAX)(PK) | | | | | |
|---|---|---|---|---|---|---|---|---|
| CONDITIONS AND LIMITS | $V_R$ = 200V | | $I_F$ = 38A(PK) (PULSED) | | | | | |
| IDENTIFICATION | GE | INR | GE | INR | | | | |
| INITIAL DATA | | | | | | | | |
| MIN VALUE | 52.10nA | 2.130nA | 1.144V | 1.064V | | | | |
| MAX VALUE | 42.60μA | 4.330μA | 1.215V | 1.195V | | | | |
| MEAN | 2.841μA | 332.7nA | 1.176V | 1.114V | | | | |
| STD DEV | 10.27μA | 1.049μA | 21.95mV | 32.41mV | | | | |
| INTERIM DATA | | | | | | | | |
| POWER 150 TO 175% Δ MEAN VALUE | | | | | | | | |
| 150% POWER | | | | | | | | |
| 1510 HRS | -0.618μA | 210.8nA | 7.00mV | 35.0mV | | | | |
| 1525 HRS | 1.663μA | 6.251μA | 7.00mV | 31.0mV | | | | |
| 1550 HRS | 3.804μA | 3.053μA | 8.00mV | 31.0mV | | | | |
| 1650 HRS | 1.270μA | 2.089μA | 5.00mV | 31.0mV | | | | |
| 1750 HRS | 15.37μA | -27.50nA | 18.00mV | 35.0mV | | | | |
| 2000 HRS | *20.98μA | *5.848μA | 11.00mV | 26.0mV | | | | |
| 175% POWER | | | | | | | | |
| 2010 HRS | 6.731μA | 482.5nA | 12.0mV | 16.0mV | | | | |
| 2025 HRS | 19.69μA | JOB STOPPED | 12.0mV | JOB STOPPED | | | | |
| 2050 HRS | 46.48μA | JOB STOPPED | 12.0mV | JOB STOPPED | | | | |
| 2150 HRS | 4.841μA | JOB STOPPED | 24.0mV | JOB STOPPED | | | | |
| 2250 HRS | 7.829μA | JOB STOPPED | 46.0mV | JOB STOPPED | | | | |
| 2500 HRS | 7.799μA | JOB STOPPED | -79.0mV | JOB STOPPED | | | | |
| FINAL DATA | | | | | | | | |
| MIN VALUE | 99.90nA | 7.410nA | 510.0mV | 1.110V | | | | |
| MAX VALUE | 67.00nA | 5.110μA | 1.220V | 1.160V | | | | |
| MEAN | 10.64μA | 815.2nA | 1.097V | 1.130V | | | | |
| STD DEV | 21.99μA | 1.541μA | 190.1mV | 20.62mV | | | | |

*NOTE: CATASTROPHIC REJECT(S) REMOVED FROM DATA AFTER THIS POINT.

TABLE 5

GROUP II TEMP STRESS I DATA SUMMARY

| PARAMETERS | $I_R$ = 50μA (MAX) | | $V_F$=1.35V(MAX)(PK) | | | | | |
|---|---|---|---|---|---|---|---|---|
| CONDITIONS AND LIMITS | $V_R$ = 200 V | | $I_F$ = 38(PK) (PULSED) | | | | | |
| IDENTIFICATION | GE | INR | GE | INR | | | | |
| INITIAL DATA | | | | | | | | |
| MIN VALUE | 37.40nA | 2.310nA | 1.160V | 1.110V | | | | |
| MAX VALUE | 1.550μA | 409.0nA | 1.310V | 1.460V | | | | |
| MEAN | 247.9nA | 40.36nA | 1.202V | 1.269V | | | | |
| STD DEV | 386.4nA | 98.70nA | 35.04mV | 88.49mV | | | | |
| INTERIM DATA (INITIAL TO FINAL) | | | | | | | | |
| Δ MEAN VALUE | | | | | | | | |
| TOTAL HRS / TEMP ($T_A$) | | | | | | | | |
| 160 / 75°C | 10.05μA | *53.64nA | 1.0mV | 35.0mV | | | | |
| 320 / 100°C | -247.7nA | JOB STOPPED | 2.0mV | JOB STOPPED | | | | |
| 480 / 125°C | -221.8nA | JOB STOPPED | 2.0mV | JOB STOPPED | | | | |
| 640 / 150°C | *631.2μA | JOB STOPPED | 18.0mV | JOB STOPPED | | | | |
| 800 / 175°C | *666.0μA | JOB STOPPED | 52.0mV | JOB STOPPED | | | | |
| 960 / 200°C | 5.700nA | JOB STOPPED | 54.0mV | JOB STOPPED | | | | |
| 1120 / 225°C | JOB STOPPED | JOB STOPPED | JOB STOPPED | JOB STOPPED | | | | |
| 1280 / 250°C | JOB STOPPED | JOB STOPPED | JOB STOPPED | JOB STOPPED | | | | |
| 1440 / 275°C | JOB STOPPED | JOB STOPPED | JOB STOPPED | JOB STOPPED | | | | |
| 1600 / 300°C | JOB STOPPED | JOB STOPPED | JOB STOPPED | JOB STOPPED | | | | |
| FINAL DATA | 200°C | 75°C | 200°C | 75°C | | | | |
| FINAL TEMP ($T_A$) | | | | | | | | |
| MIN VALUE | 33.40nA | 2.840nA | 1.220V | 1.130V | | | | |
| MAX VALUE | 1.010μA | 1.310μA | 1.380V | 1.530V | | | | |
| MEAN | 253.6nA | 94.00nA | 1.256V | 1.304V | | | | |
| STD DEV | 378.7nA | 314.4nA | 62.48mV | 113.9mV | | | | |

* NOTE: CATASTROPHIC REJECT(S) REMOVED FROM DATA AFTER THIS POINT.

TABLE 6

GROUP III TEMP STRESS II DATA SUMMARY (16 HR)

| PARAMETERS | $I_R$ = 50μA (MAX) | | $V_F$ = 1.35V(MAX) (PM) | | | | | |
|---|---|---|---|---|---|---|---|---|
| CONDITIONS AND LIMITS | $V_R$ = 200V | | $I_F$ = 38A (PK) (PULSED) | | | | | |
| IDENTIFICATION | GE | INR | GE | INR | | | | |
| INITIAL DATA | | | | | | | | |
| MIN VALUE | 20.60nA | 1.630nA | 1.120V | 1.020V | | | | |
| MAX VALUE | 463.0nA | 1.630μA | 1.220V | 1.190V | | | | |
| MEAN | 175.6nA | 203.5nA | 1.168V | 1.109V | | | | |
| STD DEV | 127.2nA | 449.6nA | 25.62mV | 40.45mV | | | | |
| INTERIM DATA (INITIAL TO FINAL) | | | | | | | | |
| Δ MEAN VALUE | | | | | | | | |
| TOTAL HRS / TEMP ($T_A$) | | | | | | | | |
| 16 / 150°C | 59.91μA | 40.1nA | 2.0mV | 2.0mV | | | | |
| 32 / 175°C | 40.93μA | -73.9nA | 5.0mV | 5.0mV | | | | |
| 48 / 200°C | 1.162μA | -114.4nA | 38.0mV | 38.0mV | | | | |
| 64 / 225°C | 15.86μA | -120.6nA | 28.0mV | 45.0mV | | | | |
| 80 / 250°C | 14.38μA | *1.332mA | 38.0mV | 78.0mV | | | | |
| 96 / 275°C | *1.139mA | *1.816mA | 49.0mV | 154.0mV | | | | |
| 112 / 300°C | 32.74μA | 38.13μA | 70.0mV | 56.0mV | | | | |
| FINAL DATA | | | | | | | | |
| FINAL TEMP ($T_A$) | 300°C | 300°C | 300°C | 300°C | | | | |
| MIN VALUE | 68.30nA | 4.860nA | 1.180V | 1.120V | | | | |
| MAX VALUE | 337.0μA | 297.0μA | 1.460V | 1.250V | | | | |
| MEAN | 32.92μA | 38.32μA | 1.238V | 1.165V | | | | |
| STD DEV | 89.12μA | 97.81μA | 71.63mV | 37.75mV | | | | |

* NOTE: CATASTROPHIC REJECT(S) REMOVED FROM DATA AFTER THIS POINT.

DCA

TABLE 7
FINAL DATA SUMMARY

| PARAMETER | SPECIFICATIONS LIMIT | | UNITS | MEAN INT. DATA | AVERAGE Δ IN MEAN VALUE | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | POWER STRESS | | TEMPERATURE STRESS I | | TEMPERATURE STRESS II | |
| | MIN | MAX | | | GE | INR | GE | INR | GE | INR |
| $I_R$ | | 50.0 | μA | | *+32.772 | *+1.0457 | *+217.80 | +.05364 | *+186.28 | *+455.12 |
| $V_F$ | | 1.35 | V | | +.00871 | +.02638 | +.02150 | +.03500 | +03286 | +.05400 |
| | | | | | | | | | | |
| | | | | | | | | | | |

* NOTE: CATASTROPHIC REJECT(S) REMOVED FROM DATA AFTER THIS POINT.

TABLE 8 STEP STRESS CATASTROPHIC FAILURE SUMMARY JANTX1N1202A

GROUP I POWER STRESS

| TEST STEP | MFR A | | MFR B | |
|---|---|---|---|---|
| | QTY. | NOTE | QTY. | NOTE |
| 50% 50 hr. | 0 | - | 0 | - |
| 100 hr. | 0 | - | 0 | - |
| 100 hr. | 0 | - | 0 | - |
| 250 hr. | 0 | - | 0 | - |
| 100% 50 hr. | 2 | A | 4 \ 1 | A \ B |
| 100 hr. | 0 | - | 0 | - |
| 100 hr. | 0 | - | 0 | - |
| 250 hr. | 0 | - | 0 | - |
| 125% 10 hr. | 0 | - | 0 | - |
| 15 hr. | 0 | - | 0 | - |
| 25 hr. | 0 | - | 0 | - |
| 100 hr. | 0 | - | 0 | - |
| 100 hr. | 0 | - | 0 | - |
| 250 hr. | 1 | A | 0 | - |
| 150% 10 hr. | 0 | - | 0 | - |
| 15 hr. | 0 | - | 0 | - |
| 25 hr. | 0 | - | 0 | - |
| 100 hr. | 0 | - | 0 | - |
| 100 hr. | 0 | - | 2 | A |
| 250 hr. | 1 | A | 1 | B |
| 175% 10 hr. | 0 | - | JOB STOPPED | |
| 15 hr. | 0 | - | JOB STOPPED | |
| 25 hr. | 0 | - | JOB STOPPED | |
| 100 hr. | 0 | - | JOB STOPPED | |
| 100 hr. | 0 | - | JOB STOPPED | |
| 250 hr. | 0 | - | JOB STOPPED | |

GROUP II 160 HR. TEMP. STEPS

| TEST STEP ($T_A$) | MFR A | | MFR B | |
|---|---|---|---|---|
| | QTY. | NOTE | QTY. | NOTE |
| 75° C | 0 | - | 3 | C |
| 100° C | 0 | - | JOB STOPPED | |
| 125°C | 0 | - | JOB STOPPED | |
| 150°C | 1 | A | JOB STOPPED | |
| 175°C | 1 | A | JOB STOPPED | |
| 200°C | 10 | C | JOB STOPPED | |
| 225°C | JOB STOPPED | | JOB STOPPED | |
| 250°C | JOB STOPPED | | JOB STOPPED | |
| 275°C | JOB STOPPED | | JOB STOPPED | |
| 300°C | JOB STOPPED | | JOB STOPPED | |

GROUP III 16 HR. TEMP. STEPS

| TEST STEP ($T_A$) | MFR A | | MFR B | |
|---|---|---|---|---|
| | QTY. | NOTE | QTY. | NOTE |
| 150°C | 0 | - | 0 | - |
| 175°C | 0 | - | 0 | - |
| 200°C | 0 | - | 0 | - |
| 225°C | 0 | - | 0 | - |
| 250°C | 0 | - | 2 | A |
| 275°C | 2 | A | 2 | A |
| 300°C | 0 | - | 0 | - |

MFR "A" - GENERAL ELECTRIC

MFR "B" - INTERNATIONAL RECTIFIER

NOTES: A - $I_R$ > 5mA

B - $V_F$ > 2.025V

C - VISUAL (OTHER THAN HANDLING)

TABLE 9 STEP STRESS PARAMETRIC FAILURE SUMMARY JANTX1N1202A

GROUP I POWER STRESS

| TEST STEP | MFR A | | MFR B | |
|---|---|---|---|---|
| | QTY. | NOTE | QTY. | NOTE |
| 50% 50 hr. | 0 | – | 0 | – |
| 100 hr. | 0 | – | 0 | – |
| 100 hr. | 0 | – | 0 | – |
| 250 hr. | 0 | – | 0 | – |
| 100% 50 hr. | 0 | – | 0 | – |
| 100 hr. | 0 | – | 0 | – |
| 100 hr. | 0 | – | 0 | – |
| 250 hr. | 0 | – | 1 | B |
| 125% 10 hr. | 0 | – | 0 | – |
| 15 hr. | 0 | – | 0 | – |
| 25 hr. | 0 | – | 0 | – |
| 100 hr. | 0 | – | 0 | – |
| 100 hr. | 0 | – | 0 | – |
| 250 hr. | 0 | – | 0 | – |
| 150% 10 hr. | 0 | – | 0 | – |
| 15 hr. | 0 | – | 1 | A |
| 25 hr. | 0 | – | 0 | – |
| 100 hr. | 0 | – | 0 | – |
| 100 hr. | 1 | A | 0 | – |
| 250 hr. | 1 | A | 0 | – |
| 175% 10 hr. | 0 | – | 0 | – |
| 15 hr. | 0 | – | JOB STOPPED | |
| 25 hr. | 0 | – | JOB STOPPED | |
| 100 hr. | 0 | – | JOB STOPPED | |
| 100 hr. | 1 | A | JOB STOPPED | |
| 250 hr. | 0 | – | JOB STOPPED | |

GROUP II 160 HR. TEMP. STEPS

| TEST STEP ($T_A$) | MFR A | | MFR B | |
|---|---|---|---|---|
| | QTY. | NOTE | QTY. | NOTE |
| 75°C | 1 | A | 2 \ 6 | B \ F |
| 100°C | 0 | – | JOB STOPPED | |
| 125°C | 0 | – | JOB STOPPED | |
| 150°C | 1 | A | JOB STOPPED | |
| 175°C | 1 | – | JOB STOPPED | |
| 200°C | 0 | – | JOB STOPPED | |
| 225°C | JOB STOPPED | | JOB STOPPED | |
| 250°C | JOB STOPPED | | JOB STOPPED | |
| 275°C | JOB STOPPED | | JOB STOPPED | |
| 300°C | JOB STOPPED | | JOB STOPPED | |

GROUP III 16 HR. TEMP. STEPS

| TEST STEP ($T_A$) | MFR A | | MFR B | |
|---|---|---|---|---|
| | QTY. | NOTE | QTY. | NOTE |
| 150°C | 4 | A | 0 | – |
| 175°C | 0 | – | 0 | – |
| 200°C | 0 | – | 2 | C |
| 225°C | 2 | A | 1 | B |
| 250°C | – | – | 1 | D |
| 275°C | 2 | A | 1 \ 1 | E \ B |
| 300°C | – | – | 1 | A |

MFR "A" - GENERAL ELECTRIC

MFR "B" - INTERNATIONAL RECTIFIER

NOTES:
A - $I_R$ LIMIT FAILURE
B - $V_F$ LIMIT FAILURE
C - S/N 9379, 9390 REMOVED FROM TESTING AS MIL-S-19500 FAILURE
D - S/N 9382 REMOVED FROM TESTING AS MIL-S-19500 FAILURE
E - S/N 9384 REMOVED FROM TESTING AS MIL-S-19500 FAILURE
F - S/N 9395, 9398, 9400, 9402, 9408, 9403 VISUAL DUE TO HANDLING

# APPENDIX
# FAILURE ANALYSIS

# FAILURE ANALYSIS
POWER STRESS

**Date** 27 October 1978

**J/N** 2CN242-27A **P/N** 1N1202A **MFR** INTERNATIONAL RECTIFIER

**FAILURE VERIFICATION:**

| S/N | | PIV -volts- | $I_R$ @ 200 V.dc | $V_F$ @ 38 A dc | INITIAL REJ. AT TEST SEQUENCE NO.: | INITIAL REJ. FOR: |
|---|---|---|---|---|---|---|
| )362 | | 450 Uns arcs | ∞ | No reading | 41 (150% pwr) (200 Hr. Tot) | $I_R$ |
| )365 | | R=150 | ∞ | 5.4 | 11 (100% pwr) (550 Hr. Tot) | $I_R$ |
| )366 | | R=800 | ∞ | 5.5 | 11 (100% pwr) (550 Hr. Tot) | $I_R$ |
| | | | | | | |

INTERNAL VISUAL INSPECTION:

S/N 9362: The semiconductor die and its metal mounting disc are detached from the stud; the silicon junction coating material is completely charred and burned off the die. (See Figure A-1.)

S/N 9365: The large metal balls are wedged between the semiconductor die and the side of the case. (See Figure A-2.)

S/N 9366: This sample has no significant visual defects.

CONCLUSION:

These rectifiers failed due to the thermal effects of the excess power stress test. The failure modes included melting bonding material which disconnected and shorted internal die connections; contamination and chemical changes to the junction coating; and alloying of the bonding material with the silicon.

*$h_{FE}$ trace present. Cannot meet stated test conditions. (Leaky)
**$h_{FE}$ trace very leaky.

D=drift H=hysteresis Inv=inversion R=resistive S=soft Uns=unstable

FAILURE ANALYSIS

APPENDIX B

TEMPERATURE STRESS

## FAILURE ANALYSIS
TEMPERATURE STRESS

**Date** 30 October 1978

**J/N** 2CN242-27B **P/N** 1N1202A **MFR** INTERNATIONAL RECTIFIER

**FAILURE VERIFICATION:**

| S/N | | PIV -volts- | $I_R$ @ 200 V.dc | $V_F$ @ 38 A dc | INITIAL REJ. AT TEST SEQUENCE NO.: | INITIAL REJ. FOR: |
|---|---|---|---|---|---|---|
| 9391 | | --- | --- | --- | 3 (+75°C) (160 Hrs. Tot) | Missing lead and tube |
| 9401 | | >1100 | <0.1μA | 5.4 | 3 (+75°C) (160 Hrs. Tot) | Missing G/M seal & eyelet |
| 9405 | | open | open | open | 3 (+75°C) (160 Hrs. Tot) | Loose eyelet; cracked glass |
| | | | | | | |

NTERNAL VISUAL INSPECTION:

The glass-to-metal seal has come apart on all three International Rectifier samples. S/N 9391 and 9401 the tubulation was missing in the parts as received for analysis; on S/N 9405 the tube is still in place, but it can be moved within the glass seal. (See Figures B-1 and B-2.) S/N 9391 has the broken-off stub of the internal wire lead still in place on the die; S/N 9401 has the internal wire lead broken off at the height of the former crimp, and S/N 9405 has separated between the silicon die and its top metal disc contact, which is loose in the package. Most of the internal wire is missing.

*$h_{FE}$ trace present. Cannot meet stated test conditions. (Leaky)
*$h_{FE}$ trace very leaky.

D=drift H=hysteresis Inv=inversion R=resistive S=soft Uns=unstable

## FAILURE ANALYSIS

TEMPERATURE STRESS

**Date** 30 October 1978

**J/N** 2CN242-27B **P/N** 1N1202A **MFR** GENERAL ELECTRIC

**FAILURE VERIFICATION:** Limit: 50 mA Max. Limit: 2.03 V Max.

| S/N | | PIV -volts- | $I_R$ @ 200 V.dc | $V_F$ @ 38 A dc | INITIAL REJ. AT TEST SEQUENCE NO.: | INITIAL REJ. FOR: |
|---|---|---|---|---|---|---|
| 9342 | | open | open | open | 13 (200°C) (960 Hrs. Tot) | Loose tube |
| )346 | | open | open | open | 13 (200°C) (960 Hrs. Tot) | Loose tube |
| )348 | | 700 → 300 arcs | 0.1μA | no reading | 13 (200°C) (960 Hrs. Tot) | Loose tube |
| | | | | | | |

INTERNAL VISUAL INSPECTION:

The glass-to-metal seals of all three General Electric samples have loosened, and the metal tubulations can be moved where they pass through the glass. (See Figure B-3.) The internal wires have separated where they were attached to the top metal contact plate of the silicon cell. (See Figure B-4.)

*$h_{FE}$ trace present. Cannot meet stated test conditions. (Leaky)
*$h_{FE}$ trace very leaky.

D=drift H=hysteresis Inv=inversion R=resistive S=soft Uns=unstable

CONCLUSION:

ALL THE IRC and GE samples failed because they were unable to withstand the high temperature developed by the thermal stress test. There was universal failure of the seal between the tubulation and glass. The GE samples also exhibit a major weak point where the internal wire lead is attached to the active cell. (See Figure B-4).

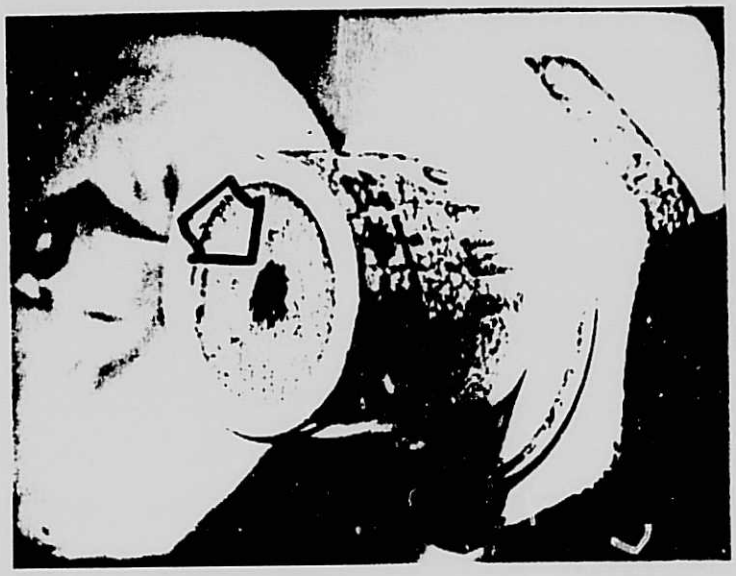


FIGURE B-1

S/N 9391, IRC SAMPLE, 5X.
Arrow indicates site of former
glass-to-metal seal.

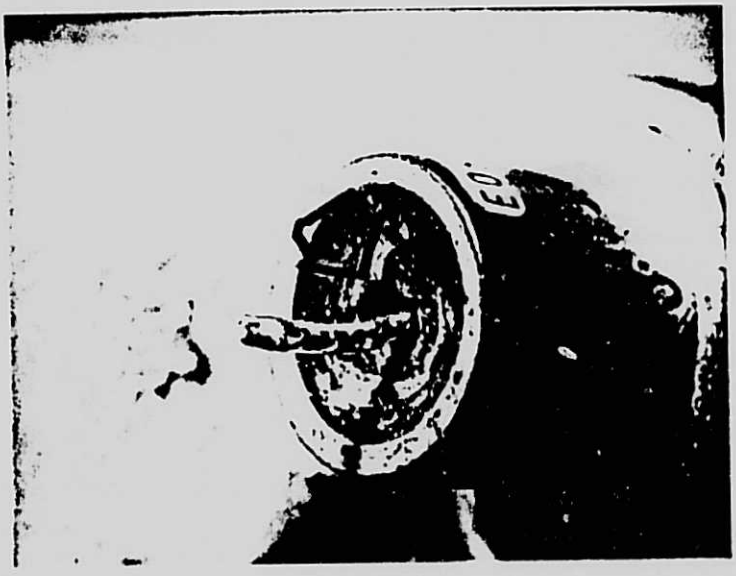


FIGURE B-2

S/N 9401, IRC SAMPLE, 5X.
Arrow indicates destroyed
glass-to-metal seal.

FIGURE A-1

S/N 9362, IRC SAMPLE, 3.3X.
Internal view of IRC device showing the silicon die detached from the stud.

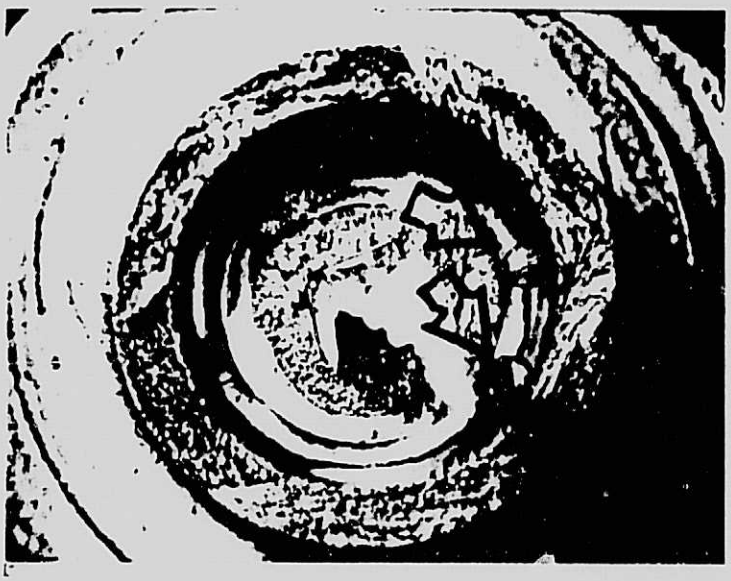


FIGURE A-2

S/N 9365, IRC SAMPLE, 9X.
Arrows indicate metal balls at the edge of the semiconductor die.

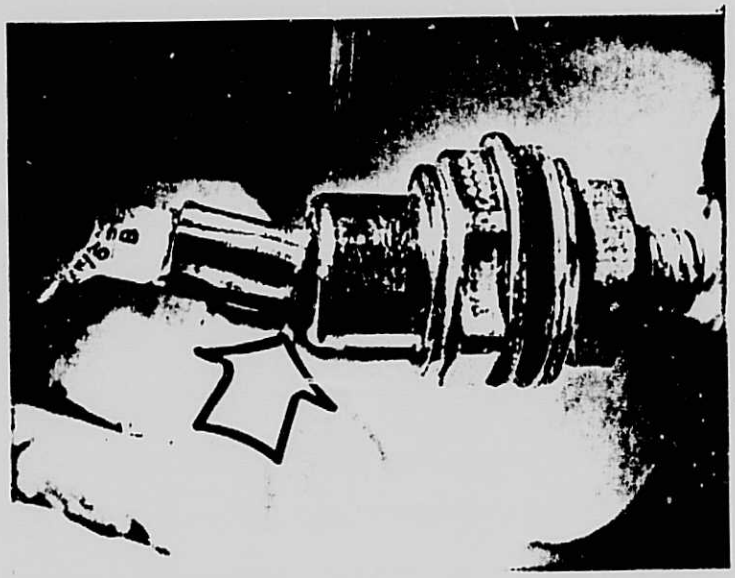


FIGURE B-3

S/N 9348, GENERAL ELECTRIC SAMPLE, 2.7X.
Arrow indicates loosened glass-to-metal seal, with movable tubulation.

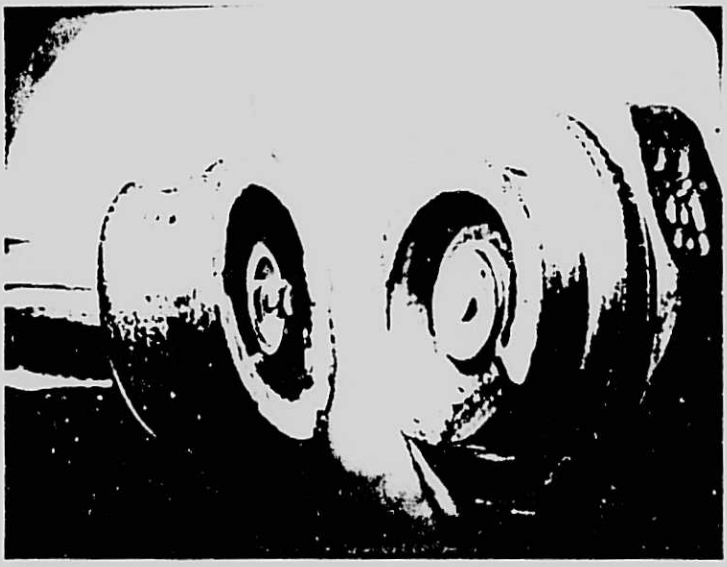


FIGURE B-4

S/N 9348, GENERAL ELECTRIC SAMPLE, 5X.
Internal view showing separation of internal wire attachment.